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論文 Article

# Influences of riverside vegetation on the health of ‘Gogi’ char

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**Abstract:** Relationships between the riverside vegetation and the health of a subspecies of Japanese common char, *Salvelinus leucomaenis imbrius* (‘Gogi’) were studied in the Chugoku Mountains. The densities of riverside vegetation comprising deciduous broad-leaf and evergreen coniferous trees, food environments comprising benthic and flowing aquatic animals and falling terrestrial animals, and the relative liver weight of char were examined. It is suggested that a high density of deciduous broad-leaf trees provides a good food environment, resulting in sound health of Gogi char.
**Keywords:** montainous stream, deciduous tree, aquatic insect, Gogi, health

## Ⅰ. Introduction

*Salvelinus leucomaenis imbrius* (Jordan et McGregor) (called ‘Gogi’) is a subspecies of the Japanese common char, *Salvelinus leucomaenis* (Pallas) (called ‘Iwana’). Gogi can be distinguished from other subspecies in the possession of clear white spots on the dorsal surface of the snout (Hosoya, 2000). It is distributed only in the western Chugoku Mountain Chains, and is biologically very important in that the distribution is the southernmost in the world. However, the population of Gogi was estimated to be gradually diminishing in every region. A pressure by fishing is considered to be a major cause to this decline. On the other hand, the changes in riverside environments such as water flow and quality, riverbed structure and riverbank vegetation seem to have strongly influenced on the Gogi populations. Indeed, in the headwaters in the temperate zone, falling leaves and branches are known to have an important role in food web of rivers, comprising aquatic insects as natural foods for fishes (Neiman and Decamps, 1997). However, the impacts of human activities such as modification of vegetation on health of population of stream fishes have not been clarified yet.

In this study, the influences of changes in riverbank vegetation from deciduous broad-leaf to evergreen coniferous trees was studied on health of Gogi char in 2 major distribution rivers in the western Chugoku Mountains, the Ohta and Takatsu Rivers, and the differences in influences on biomass of natural foods and on the health of fish were compared between these tree types, and the factors determining the differences were discussed .

## Ⅱ. Materials and Methods

### 1. Research fields

Ohta and Takatsu Rivers were selected due to their facing across the Chugoku Mountains and their relatively large sizes of Gogi populations (Fig. 1). Ohta River originates in Mt. Kanmuri (1,339m) and flows into Hiroshima Bay, with 110km in length and 1,690m$^2$ in catchment area, and Takatsu River originates in Tanohara (960m) and flows into the Sea of Japan, with 81km in length and 1,090m$^2$ in catchment area. Five and 4 sampling stations were set for Ohta and Takatsu Rivers, respectively. At St. 8, 2 sites, St. 8-1 (upper reach) and 8-2 (lower reach), were set due to a drastic change in vegetation. Investigation was conducted in April to August, 2005 and 2006. Altitude and gradient were in the ranges of

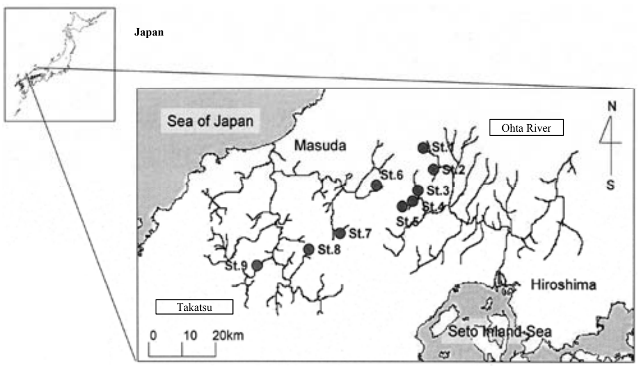


Fig. 1 Map of Ohta and Takatsu Rivers, showing the 9 sampling stations.

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Table 1 Environmental conditions and char samples.

| St. | River | Branch | Altitude (m) | Gradient (%) | Topographic type | Electric conductivity (μS/cm) | Broad-leaf tree (No./500m$^2$) | Coniferous tree (No./500m$^2$) | Char samples (No. indiv.) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Ohta | Takano | 610 | 5.4 | Aa | 18 | 9 | 81 | 9 |
| 2 | Ohta | Osa | 620 | 5.6 | Aa | 16 | 45 | 46 | 13 |
| 3 | Ohta | Yokogo | 740 | 7.2 | Aa | 18 | 32 | 28 | 14 |
| 4 | Ohta | Ushigoya | 720 | 6.8 | Aa | 21 | 17 | 67 | 21 |
| 5 | Ohta | Tashiro | 760 | 7.6 | Aa | 18 | 88 | 19 | 16 |
| 6 | Takatsu | Hiromi | 620 | 7.1 | Aa | 20 | 65 | 20 | 19 |
| 7 | Takatsu | Kamiso | 650 | 6.1 | Aa | 19 | 40 | 1 | 16 |
| 8-1 | Takatsu | Takajiri (upper reach) | 610 | 6.2 | Aa | 18 | 51 | 11 | 10 |
| 8-2 | Takatsu | Takajiri (lower reach) | 590 | 6.2 | Aa | 18 | 13 | 40 | 26 |
| 9 | Takatsu | Fukugawa | 640 | 5.8 | Aa | 18 | 80 | 0 | 9 |

590-760m and 5.4-7.6 (%), respectively (Table 1). Water quality was very good for all the stations with a range of 16-21μS/cm in electric conductivity. Topographic type of the stream was Aa based on Kani (1944) at all the stations.

## 2. Sample collection

Char samples were collected by fishing with earthworm as bait.

## 3. Environmental measurements

Environmental conditions were investigated once during May to August, 2006.

### 3-1. Vegetation

Riverside vegetation was examined in an area (500m$^2$) of 5m from water line at both sides × 50m at the station (Fig. 2), using the methods described in Sasaki (1973). All the trees of >10cm in trunk diameter at a height of 1.8m above ground were identified, counted, and categorized into deciduous or evergreen broad-leaf or coniferous trees.

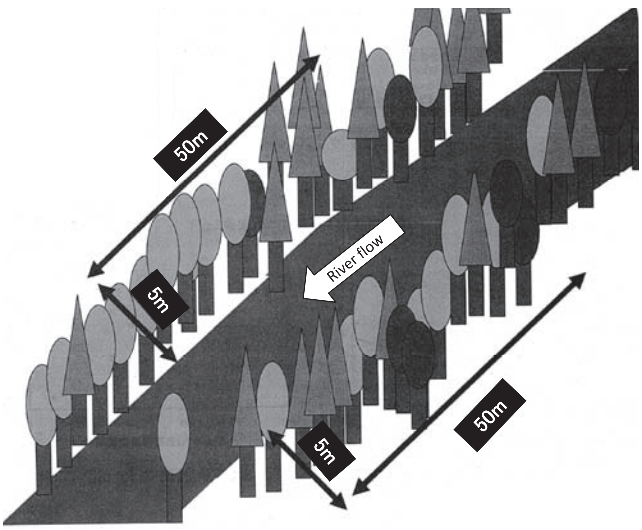


Fig. 2 Research method of riverbank vegetation.

### 3-2. Biomass of fish baits

Benthic aquatic animals were collected as a set of 3 transectional × 5 longitudinal quadrat samples (30 × 30cm) in a topographic unit of stream. Flowing aquatic animals were collected with a net of W31cm × H28.5cm (0.5mm in mesh), set at the bottom of about 10cm in depth and about 30cm/sec in velocity for 24hrs. Falling terrestrial animals were collected with a container (40 × 30cm in opening), filled with water containing some detergents, set at the forest bottom around the station overnight.

## 4. Fish conditions

Fish were measured for total length and body weight, and the liver was dissected out and weighed. Relative weight of liver was calculated by the following formula and used as an indicator of health of fish.

Relative weight of liver (%) = liver weight (g)/body weight (g) × 100

## 5. Statistical analysis

Significance of the correlation coefficients among parameters was analyzed using Student's t-test.

# Ⅲ. Results

## 1. Char samples

Seventy three and 80 samples were collected from Ohta and Takatsu Rivers, respectively (Table 1). The number of samples was the lowest at St. 1 and St. 9 and the highest at St. 8-2.

 

## 2. Vegetation

Neither evergreen broad-leaf nor deciduous coniferous trees were observed in any stations (Table 1). Deciduous broad-leaf trees were composed mainly by *Quercus crispula* and partly by *Q. serrata* and *Fagus crenata*. Evergreen coniferous trees were composed mainly by *Cryptomeria japonica* and *Chamaecyparis obtusa*. Tree densities were quite different from station to station, and broad-leaf and coniferous trees were in the ranges of 9-88 and 0-81/500m$^2$, respectively.

## 3. Relationships between tree density and benthic aquatic animal biomass (Fig. 3)

There was an apparent positive relationship between density of deciduous broad-leaf trees on the riverbank and biomass of benthic aquatic animals, although it was not significant whereas there was a significant negative relationship between density of evergreen coniferous tree and biomass of benthic aquatic animals.

## 4. Relationships between tree density and flowing animal biomass (Fig. 4)

There was a significant positive relationship between deciduous tree density and flowing aquatic animal biomass whereas there was an apparent negative relationship between coniferous tree density and flowing aquatic animal biomass, although it was not significant.

## 5. Relationships between tree density and falling terrestrial animal biomass (Fig. 5)

There was a significant positive relationship between deciduous tree density and falling terrestrial animal biomass whereas there was an apparent negative relationship between coniferous tree density and falling terrestrial animal biomass, although it was not significant.

## 6. Relationships between tree density and relative liver weight of Gogi (Fig. 6)

There was a significant positive relationship between deciduous tree density and an average relative liver weight whereas there was an apparent negative relationship between coniferous tree density and an average relative liver weight, although it was not significant.

## Ⅳ. Discussion

In this study, influence of density and composition

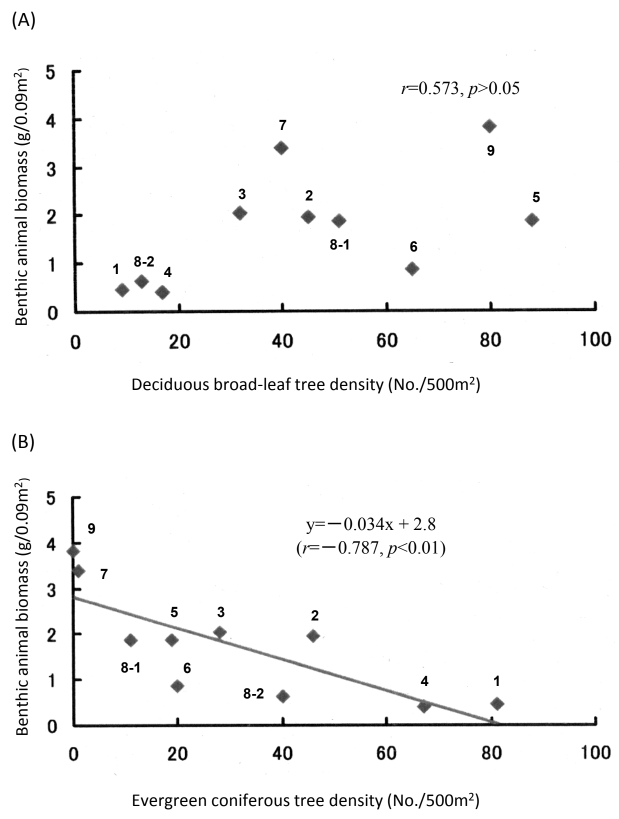


Fig. 3 Relationships between tree density and benthic aquatic animal biomass

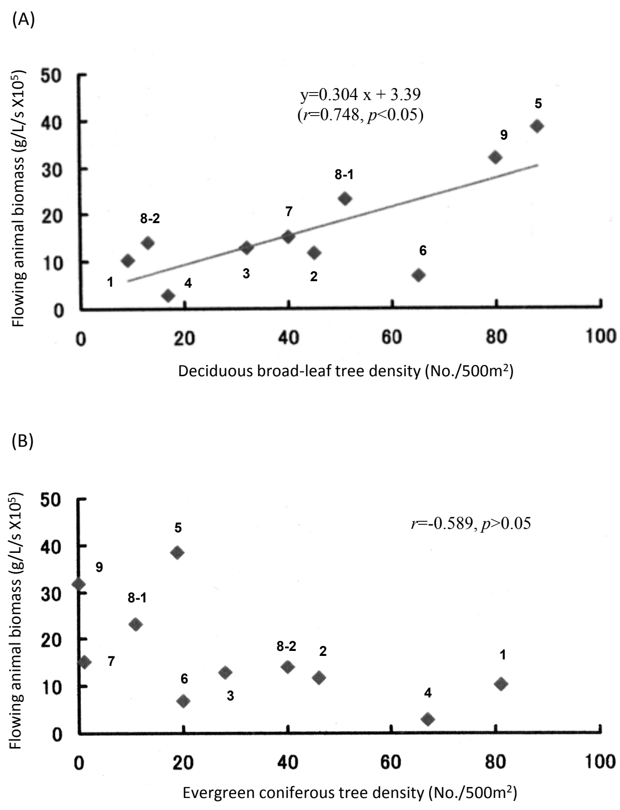


Fig. 4 Relationships between tree density and flowing aqatic animal biomass

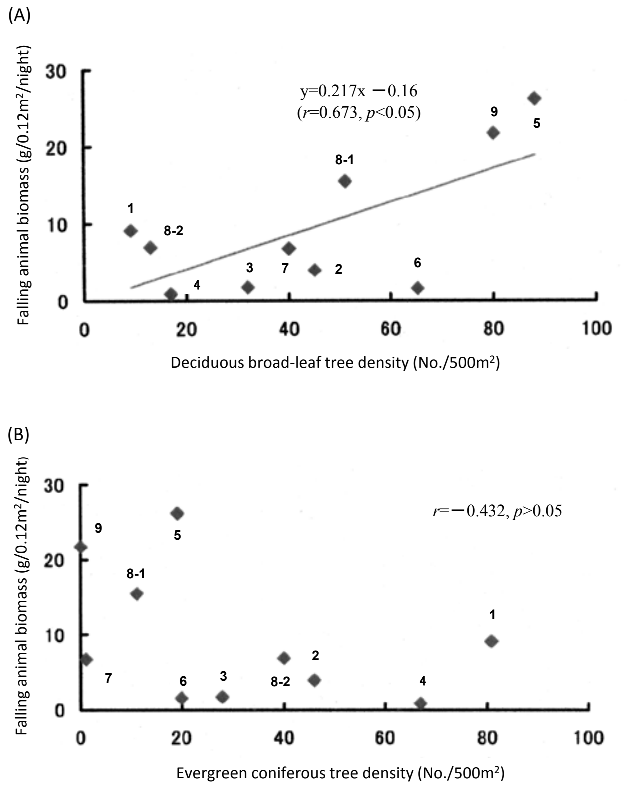


Fig. 5 Relationships between tree density and falling terrestrial animal biomass

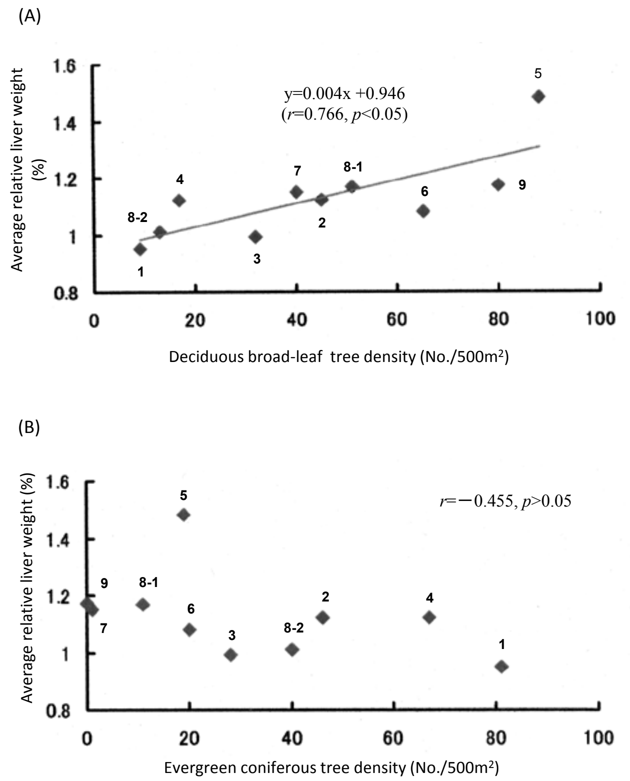


Fig. 6 Relationships between tree density and relative liver weight of Gogi

of riverside vegetation was studied on the health of Gogi char with relative liver weight as an indicator of health, and it was suggested that the higher the density of deciduous broad-leaf trees are, the better the food environments for Gogi are, resulting into a good health condition.

Relative liver weight was used as an indicator of health for fish in stead of fatness, because it was reported to show no seasonal fluctuation excepting the period between October and March (reproductive season), little changes with body length and no influences by density effects under usual densities (Kouno et al., 2004).

Relationships between dense deciduous broad-leaf trees and healthy Gogi population can be explained in the followings. At first, deciduous broad-leaf trees are considered to be favorable to a variety of insect larvae such as moths and butterflies due to their soft nature and a high level of nutrition. Thus, they are likely to be a major provider of terrestrial insects as accidental foods for fishes. Indeed, there was a significant positive relationship between deciduous tree density and falling terrestrial animal biomass in this study. Terrestrial arthropods have been reported to fall into river course and to be an important natural baits for fishes (Manson & MacDonald, 1982). Besides, land-locked salmonids are also known to depend on terrestrial falling animals as a bait in summer season (Kawaguchi & Nakano, 2001).

Secondly, deciduous broad-leaf trees are also considered to provide mountain streams with a large amount of nutrition for water plants via falling leaves and branches due to their rapid bacterial degradation in water. Thus, they can promote proliferation of water plants, especially algae, developed on the rock or gravel surface. Water plants are in turn fed by herbivorous aquatic animals such as mayflies, chironomids and snails, which in turn are fed by carnivorous animals such as stoneflies, dragonflies and some caddisflies, resulting into a good circulation of materials and an efficient production of organisms. Easy penetration of lights through deciduous leaves also may promote plant photosynthesis. Indeed, there was a significant negative relationship between density of coniferous tree and benthic aquatic animal biomass, and there was a significant positive relationship between deciduous tree density and flowing aquatic animal biomass.This can be easily explained by a low palatability of coniferous trees to terrestrial insects, their very slow bacterial degradation due to the possession of wax-like materials and their little light permeability. Besides, there was a significant positive relationship between deciduous tree density and biomass of flowing aquatic animals.

In addition, riverside vegetation was reported to have some roles in maintenance of water temperature (Kawanobe & Yamamoto, 2006) by heat absorption with leaf surface. It is also considered to have roles in maintenance of water quality by filtration of water through a deep pile of fallen leaves. Furthermore, fallen down trees were reported to involve in the formation of fish habitats such as large pool (Murphy and Hall, 1981), resulting into security of habitats for larger fishes.

On the other hand, the relationships between deciduous broad-leaf trees and food environments or health were usually significant whereas the relationships between evergreen coniferous trees and those were usually not significant. This means the existence of some indirect effects of evergreen trees on these parameters. One explanation is that coniferous tree forests are often accompanied by modification of riverbank or riverbed structures since coniferous tree forests are not natural but planted in the Chugoku Mountains in general.

In this study, only relative liver weight as an indicator of health was examined for relationships to vegetation. In view of sustainability of Gogi subspecies, however, other population parameters such as fish resource level, growth, susceptibility to major pathogens and genetic structure should be taken into account in the future studies.

Furthermore, the health of fish was explained by density or composition of riverside vegetation in this study. The modification of river bank and river bed structures, accompanied with plantation or road repairing, were reported to bring remarkable changes in the environments for fish, particularly food and habitats (Tamai et al., 1993). Therefore, the impacts of human activities on stream fish populations should be assessed from a variety of viewpoints in the next study.


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